Ecodesign to strategically manage critical materials and enhance resource efficiency

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Publication date:
2013

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January 2013

Keywords

Eco-design; critical materials; resource efficiency; wind turbine manufacturer.

Introduction

Increasing energy demand and concerns about climate change have prompted the transition towards a renewable-based energy supply. Simultaneously, the issues surrounding resource efficiency and the use of critical materials have received increased attention. A rapidly growing wind turbine industry, in combination with an increasing material demand and use of critical materials, such as rare earth metals, could inadvertently hinder the benefits of this transition to clean energy. This paper builds upon a former study that investigated how European wind turbine manufacturers appraise the phenomenon of critical materials. It seeks to provide a more detailed picture by exploring how one multi-national wind turbine manufacturer uses eco-design to manage critical materials and increase resource efficiency. It concludes by critically assessing the current methods and recommending ways to achieve more significant improvements.

Increasing resource demand

Since 1980 the amount of materials extracted and consumed worldwide increased by 60%, totaling 62 billion tonnes per year in 2008 (OECD 2012). Metal ores represented the largest growth in material demand, particularly due to the growing electronics, advanced manufacturing and renewable energy sectors (Ecodesign Centre 2013).

The wind industry is expected to account for a significant share of the future energy scenario. Increasing production values, product sizes, and complexity related to the components themselves pose many future challenges to the issues of resource efficiency and critical materials.

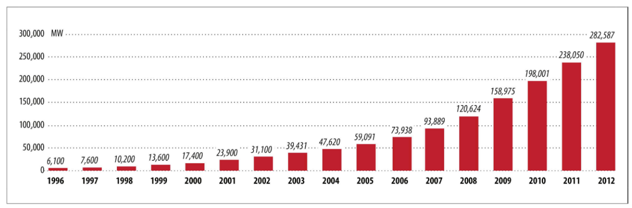

Figure 1. Increasing global cumulative installed wind capacity, 1996-2012 (GWEC 2012)

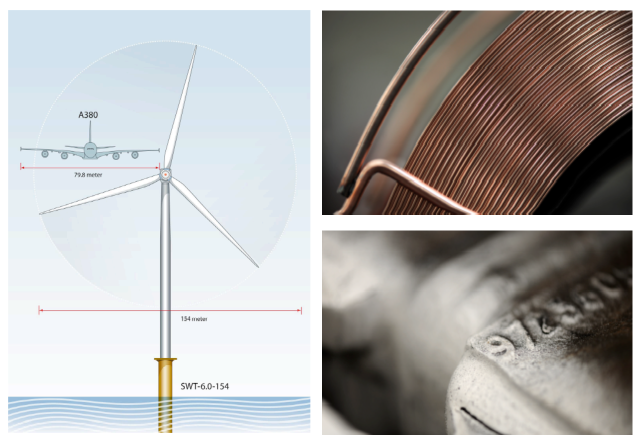

Figure 2. Increasing wind turbine size associated with increased resource use

Industry's perspective of critical materials

A recent study was conducted to determine wind turbine manufacturers' perceptions on the phenomenon of critical materials (Vroom 2012). The study concluded the following:

Current literature does not meet the needs of the wind turbine industry. For example, publications about materials used in wind turbines are non-comprehensive and little attention is given to the interactions between materials used and the industry's exponential growth. Furthermore, publications are primarily directed at governments and usually aim to support (national) policy, rather than business and industry needs.

The report also confirmed that the wind industry appears to be more aware of the issue surrounding critical materials, then companies in other industries. However, the industry fails to act homogenously. Discrepancies could be due to; 1) varying experiences related to difficulties in supply, 2) manufacturers being more inclined to give socially desirable answers, or 3) lack of clear strategy on the subject which creates difficulties for representatives to give consistent responses, both inter- and intra-organizationally.

Despite experiencing previous supply shortages, wind turbine manufacturers are overall confident about the future supply and do not foresee critical materials as being a major threat to business. Competitor strategies and suppliers are not closely followed and have limited influence on decision making. None of the manufacturers appear to have comprehensive material policies or action plans, nor are they actively formulating targets with timeframes.

The overall conclusion is that a risk exists where manufacturers could underestimate the scale of the problem and pose inadequate and untimely responses.

Managing critical materials and resource efficiency – a manufacturer's perspective

Despite a wind turbines perceived environmental benefit, there are many improvements that can be made at the product design level to improve its environmental performance. Eco-design and the circular economy are two concepts that advocate resource efficiency and challenge organizations to think in circular terms about their material flows, manufacturing processes, supply chain, business models and the lives of their products. Furthermore, material criticality literature frames both concepts as potential solutions (Peck and Bakker 2012).

In response to these facts, one wind turbine manufacturer has begun to simultaneously test and implement a number of eco-design related activities, which include:

• Life cycle assessments (LCAs) and environmental product declarations (EPDs) are being produced for each product platform using the international standards ISO14040 and ISO14044. LCAs are used as a tool to measure and improve the environmental impact of the company's products, particularly relating to material selection and use in the design and manufacturing phases, where the highest impact contributions are.

• A pilot project is being conducted to assess critical materials using an in-house evaluation scheme. A matrix evaluation based on business risk (such as future commodity price, supply availability and legislation) and exposure risks (to health and environment) is used to determine criticality.

• A process for eco-design has been developed and integrated into the PLM to ensure environmental considerations are incorporated into product development activities. This includes setting and monitoring environmental targets for every new product design and revision.

• The company also participates in a National consortium for the recycling of composites originating from the wind industry, along with other competitors and universities. The purpose is to investigate sustainable recycling technologies for plastic composites and demonstrate that the waste can be used in many different products, components and structures. The project is based on the circular economy concept.

Discussion

This section provides a critical discussion to qualitatively assess if the current eco-design activities are enough to strategically manage critical materials and achieve significant improvements in resource efficiency.

The former study on industry perspective's indicated that most wind turbine manufacturers identify critical materials based on past experience rather than through strategic measures, and do not have risk management strategies (Vroom 2012). In contrast, the manufacturer in this study does appear to have a more forward-looking approach to resource efficiency and critical materials, through its engagement in eco-design. By employing ecodesign methods, the manufacturer is able to better anticipate future legislation (e.g. RoHS, etc.) and minimize or absorb business risk such as material price increases and supply disruptions, while also improving the overall environmental profile of a product.

However, it is evident that the manufacturer is still in the development and early integration phase with the aforementioned eco-design activities. In an exploratory phase, it appears they are trying to gain a better understanding of the materials and substances within their operations. Still awaiting results of both the LCAs and critical materials assessment, there is little that can be integrated into the PLM for material management and decisions related to product development. Listed below are three recommendations that may prove valuable:

Firstly, it appears that eco-design activities continue to operate as isolated projects, separate from the PLM process and any management strategy. Policies relating to critical materials or resources in general, have not been discussed. Also, primary focus tends to be on assessment, with lack of reference to specific improvement measures. It is therefore recommended that a company specific strategy for critical materials be formulated, in addition to a formalized corporate response for external stakeholders. It is important that company policies, processes and overall business models reflect and support these concepts in order to be effective. Additionally, the assessments should be expanded to include more management related activities, such as action plans and timeframes. For example, upon completion of the LCAs and critical materials assessment, results can be integrated into the PLM in order to identify material-related targets and action plans. This could assist decisions related to sourcing, material substitutions, improving resource efficiency and recycling.

Secondly, due to the global nature of critical materials, a multi-disciplinary approach is also preferred (Vroom 2012). Participation in a national research consortium, as indicated in the previous section, is therefore an effective initiative. It bridges relevant actors from the wind turbine industry, waste handling industry, research institutes and universities; which also facilitates capacity development in the subjects of resource efficiency and waste handling.

The other eco-design activities, indicated by the manufacturer of this study, are driven primarily by EHS functions. Buy-in has been obtained by the engineering functions who loosely participate in some of the listed eco-design activities. However, ownership must be designated to both them and other relevant functions in order to achieve further improvements. For example, when the LCAs and critical materials assessment are complete material databases could be introduced for procurement and engineering functions, in order to identify critical materials and harmful substances that may be undesirable in business operations. Furthermore, meetings conducted on the subjects of critical materials and resource efficiency should also include attendants from various functions in order to enhance the discussions and ensure alternative ideas and solutions.

Thirdly, it appears that the manufacturer in this study is only assessing the direct materials (bill of materials) that end up in the final product. There is a tendency to focus on the design phase of the product and on the specific materials contained therein. This is potentially short sighted and it is therefore recommended to take a more holistic approach to critical materials. Activities and materials used outside of product design and engineering should not be excluded if the goal is to optimally attain improvements and minimize business risks throughout all stages of the product life cycle.

For example, wind turbine manufacturers often neglect the role of critical materials in production or processing equipment (Vroom 2012). Critical materials could potentially limit production capacity when these auxiliaries are considered. This would ultimately affect the supply of products themselves (e.g. wind turbines), even if all product specific ingredients remain widely available.

Conclusion

This research is based on a literature study and action research in an industrial context. It examines a wind turbine manufacturer's approach to managing critical materials. Improved resource efficiency, material substitution, sourcing alternatives and recycling can be outcomes of eco-design and ways to mitigate risks related to critical materials. The company is thereby testing and implementing a number of eco-design methods, which appears to be a viable approach.

However, it found that wider benefits could be achieved if assessments were expanded to management-related activities and linked closer to business strategies; a multi-disciplinary approach was applied to address the material issues: and the life cycle perspective was expanded beyond the materials themselves.

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